RESEARCH TRIANGLE INSTITUTE
Air Pollution Control Technology Verification Center

TO: Mobile Sources ETV Technical Panel Members
FROM: Douglas VanOsdell, Mobile Source Verification Task Leader
DATE: February 19, 2001
SUBJECT: Technical Panel Draft No. 2 of *Generic Verification Protocol for Retrofit Catalyst and Particulate Filter Control Technologies for Highway and Nonroad Use Diesel Engines*

Technical Panel Draft No. 2 of the *Generic Verification Protocol for Retrofit Air Pollution Control Technologies for Highway and Nonroad Use Diesel Engines* is attached for your review prior to the February 28 Technical Panel (TP) meeting. This "second draft" includes input from the December 8 full-TP teleconference, the December teleconferences of the testing and engine subcommittees, the January 24 full-TP meeting, and input from those who responded regarding considerations specific to different technologies. The wide right margin is for notes.

The major re-writes are in sections 2 and 5, but there are revisions through-out the protocol. The verification statement (Appendix A) still needs some work and will get some before the meeting. Following the approach agreed on in January, feed-back was obtained from several individuals regarding how to adjust the catalyst/filter engine matrix and test parameters to accommodate other technology. Input received was used to develop the new section 5.

As currently written, section 5 is conservative with regard to the use of fuels and engine modifications in that engine manufacturer endorsement to allow use of a technology will be specifically sought. This is meant to address what appear to be reasonable concerns on the part of the engine manufacturers, but could easily become a pinch point administratively. We have touched on this and similar issues at our meetings but have not really focused on it, and more discussion is needed.

Finally, one of the important principles of this protocol is harmonization with the California verification program, which is not yet finalized and is being discussed this week at CARB. Discussion of this topic will be scheduled, and a representative of CARB will be present to advise us of the latest developments in California.

As previously communicated to you, the next technical panel meeting will be in Washington, DC from 9:00 AM to 3:00 PM (Eastern Standard Time) on Wednesday, February 28, 2001. The meeting will be held in the CRYSTAL GATEWAY MARRIOTT, 1700 Jefferson Davis Highway, Arlington, VA (http://Marriotthotels.com/WASGW/default.asp). This is one of two Marriott hotels within a couple of blocks of each othe, the other being the Crystal City Marriott. I have been there, and confusion is possible. Remember: the **CRYSTAL GATEWAY** at Crystal City.

If you have any questions or comments, please contact me at (919) 541-6785 or dwv@rti.org.

GENERIC VERIFICATION PROTOCOL FOR AIR POLLUTION CONTROL TECHNOLOGIES FOR HIGHWAY AND NON-ROAD USE DIESEL ENGINES

EPA Cooperative Agreement No. CR826152-01-3
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Technical Panel Draft No. 2

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1.0 INTRODUCTION

1.1 Environmental Technology Verification

The U.S. Environmental Protection Agency (EPA) has instituted the Environmental Technology Verification (ETV) Program to verify the performance of innovative and improved technical solutions to problems that threaten human health or the environment. EPA created the ETV Program to substantially accelerate the entrance of new and improved environmental technologies into the domestic and international marketplaces. It is a voluntary, non-regulatory program.

ETV supplies technology buyers, developers, consulting engineers, and permitters with high-quality, objective data on the performance of new or improved technologies. This encourages more rapid protection of the environment with better and less expensive approaches.

The ETV Program has established verification efforts in 12 pilot areas. In these pilot programs, EPA utilizes the expertise of verification partners to design efficient processes for conducting performance tests of environmental control technologies. EPA selects its verification partners from the non-profit public and private sectors, including laboratories, state agencies, and universities. Verification partners oversee and report verification activities based on testing that follows protocols developed with input from all major stakeholder/customer groups associated with the technology area.

The ETV goal is to verify the environmental performance characteristics of commercial-ready technologies through the evaluation of objective and quality-assured data so that potential purchasers and permitters are provided with an independent and credible assessment of what they are buying and permitting.

1.2 Air Pollution Control Technology Verification Center

One of the 12 ETV pilot programs is the Air Pollution Control Technology Verification Center (APCTVC). EPA's verification partner in the APCTVC is Research Triangle Institute (RTI), a non-profit contract research organization with headquarters in Research Triangle Park, NC. The APCTVC verifies the performance of commercial-ready technologies used to control air pollutant emissions. The emphasis of the APCTVC is on technologies for controlling particulate matter, volatile organic compounds, nitrogen oxides (NO_x), and hazardous air pollutants. As the program matures, more technologies may be added.

RTI cooperatively organized and developed the APCTVC for verification testing of air pollution control technologies. The ETV program is not intended for research and development, but is intended for those technologies that are ready for the marketplace. The APCTVC decides if a product is ready for the marketplace on a case by case basis after reviewing information presented by the manufacturer. Because results are made available to the public, manufacturers are generally sure of the expected test results before submitting a technology for verification.

The APCTVC develops generic verification protocols and specific test/quality assurance (QA) plans, conducts independent testing of technologies, and prepares verification test reports and statements for broad dissemination. A goal of the APCTVC is to have all testing costs ultimately become self-sustaining, or "privatized," by operating on project-generated income (user fees) and other resources.

1.3 The Mobile Sources Air Pollution Control Technology Verification Program

Control of emissions from mobile sources continues to be of great national importance. Several areas of the country are not able to attain ambient air quality standards. The mobile source provisions of the 1990 Clean Air Act Amendments are intended to reduce most vehicle-related pollutants by more than 40 percent for 1996 and later model year vehicles and engines. Pre-existing engines emit pollutants at higher levels, and as these engine are durable and have long useful lives, they emit pollutants at higher levels many years into the future. For these reasons, the EPA funded and the APCTVC Stakeholders Advisory Committee (SAC) recommended inclusion of air pollution control technologies for mobile sources as a priority for verification.

One important group of mobile source air pollution control initiatives is concerned with highway and non-road use diesel engines. The diesel particulate standard for urban buses was reduced in 1993 by 60 percent, from 0.33 to 0.13 g/kW-h (0.25 to 0.10 g/bhp-h). The standard, which applies to urban transit buses, dropped to 0.094 g/kWh (0.07 g/bhp-h) in 1994 and to 0.067 g/kWh (0.05 g/bhp-h) in 1996. While existing engine technologies can meet these standards, future standards will be increasingly stringent and will require the use of after-treatment emissions control technologies. New technologies are being developed to meet these goals. In addition, since a NO_x emission level below the level mandated

allows the generation of credits (through the Voluntary Retrofit Program [VRP]), pollution prevention becomes more cost effective, and innovations in less-polluting alternatives and control technologies are encouraged.

Retrofit mobile source control technologies may be "add-on" or "end-of-pipe" exhaust emission control devices, engine modifications, or special fuels or lubricants that require no mechanical changes to engines. Examples of "add-on" devices are filters for particulate matter (PM) control, "add-on" fixed-bed catalytic oxidizers, and selective catalytic reduction (SCR) NOx control devices. Engine modifications, in the context of this protocol, refers to pollution reduction technologies integral to the engine or its control systems. Special fuel and lubricants refers to fuels, reformulated fuels, emulsified fuels, fuel additives, special lubricants, and lubricant additives that differ from those specified by EPA as "standard" in its various publications. Fuels and lubricants are technologies that require EPA health effects testing because they potentially introduce new components to the emissions stream. Prior registration and compliance with all federal requirements will be necessary for such technologies that may be included in the APCTVC. All these technologies have the potential to affect engine performance, and engine manufacturer concurrence that the devices are compatible with safe, efficient, and reliable operation in their engines is an important element in demonstrating commercial readiness and suitability for verification. The technologies and their testing are discussed in more detail below.

This generic verification protocol (GVP) provides the requirements for retrofit air pollution control technologies applied to highway and non-road use diesel engines. It is intended to apply to all technologies and their combinations. The APCTVC reserves the right to evaluate each technology submitted for and determine the applicability of this protocol. Special testing may be required in some cases to maintain the integrity and value of verifications. The critical data quality objectives (DQOs) in this document were chosen to provide emissions measurements sufficient to support the diesel engine voluntary retrofit program (VRP) and its emission credit provisions. Emissions credit allowances will be set by the appropriate state regulatory authority or EPA's Office of Transportation and Air Quality (OTAQ). (The VRP approving agencies may have data requirements in addition to the ETV test report.)

This protocol was developed and has been reviewed by a technical panel

comprised of a broad group of stakeholders who have mobile source control expertise. Technical panel membership is dynamic, and its composition is expected to change over several years as technical emphases change. The APCTVC will maintain balance on the panel.

As described below, the APCTVC will measure and report a baseline emissions concentration and rate for an engine prior to use of the retrofit technology and also the emissions concentrations and rate for engines following retrofit. The data quality requirements of this generic protocol will be applied at specific test laboratories for specific types of technologies through the preparation of specific test/quality assurance (QA) plans. Other laboratory-, application-, or technology-specific information may also need to be addressed in the test/QA plan, which is described in Section 10.0. In general, test/QA plans prepared by test laboratories will not be reviewed by the entire technical panel. However, because specific technology areas may require special expertise or emphasis, input and review will be obtained from an ad hoc subcommittee of the technical panel and/or outside experts when deemed appropriate. Test results will be presented as verification reports and verification statements.

1.4 Quality Management Documents

Management and testing within the Verification Program for Retrofit Air Pollution Control Technologies for Highway and Nonroad Use Diesel Engines are performed in accordance with procedures and protocols defined by the following:

1. EPA's ETV Quality and Management Plan (ETV QMP) (EPA, 1998a),
2. the APCT Quality Management Plan (QMP) (RTI, 1998),
3. the Generic Verification Protocol for Verification of Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines (this document), and
4. Test/QA plans prepared for each specific test or group of tests.

EPA's ETV QMP lays out the definitions, procedures, processes, inter-organizational relationships, and outputs that will ensure the quality of both the data and the programmatic elements of the ETV Program. Part A of the ETV QMP contains the specifications and guidelines that are applicable to common or routine quality management functions and activities necessary to support the ETV Program. Part B of the ETV QMP

contains the specifications and guidelines that apply to test-specific environmental activities involving the generation, collection, analysis, evaluation, and reporting of test data.

APCT's QMP describes the quality systems in place for the overall APCTVC. It was prepared by RTI and approved by EPA. Among other quality management items, it defines what must be covered in the generic verification protocols and test/QA plans for technologies undergoing verification testing.

Generic Verification Protocols (GVPs) are prepared to describe the general procedures to be used for testing a type of technology and define the critical data quality objectives (DQOs). The GVP for retrofit air pollution control technologies for highway and non-road use diesel engines was written by the APCTVC with input from a technical panel and approved by EPA/ORD.

Test/QA plans are prepared for each test or group of tests. Because multiple testing organizations will be conducting the tests and the desirability to ensure comparability, the APCTVC will develop a prototype test/QA plan (not part of this GVP) for each type of technology. This prototype will be customized by the testing organization to meet its specific testing arrangements. However, modifications that the APCTVC feels will compromise comparability between labs will not be approved. The test/QA plan describes, in detail, how the testing organization will implement and meet the requirements of the generic verification protocol. The test/QA plan also sets DQOs for measurements that are applicable to the technology type. The test/QA plan addresses issues such as the test organization's management structure, the test schedule, test procedures and documentation, analytical methods, data collection requirements, and instrument calibration and traceability, and it specifies the QA and quality control (QC) requirements for obtaining verification data of sufficient quantity and quality to satisfy the DQOs of the generic verification protocol. Section 10 of this GVP addresses requirements for the test/QA plan.

2.0 OBJECTIVE AND SCOPE

2.1 Objective

The objective of this GVP is to establish the parameters within which retrofit air pollution control technologies for highway and non-road use diesel engines will be tested to verify their performance with uniform and consistent methodologies. The protocol addresses the type of data that must be collected, outlines the test conditions and procedures to be used, and states the critical data quality objectives for verification. The control technologies will be verified within a specified range of applicability, and verification reports and statements will be produced for dissemination to the public.

2.2 Scope

Testing will be performed to quantify the effectiveness of commercially ready emissions control technologies that are intended for use on engines considered mobile sources of air pollutants. Emissions testing under this verification program is based on the Federal Test Procedures (FTPs) for highway engines (40 CFR Part 86) and nonroad engines (40 CFR Part 89). The FTPs are utilized by manufacturers to certify their engines as meeting Federal and California emissions regulations. The pollutants of major interest are nitrogen oxides (NO_x), hydrocarbons (HC), and particulate matter (PM). In addition, emissions of carbon monoxide (CO) and carbon dioxide (CO_2) will be measured along with other data useful for evaluating the performance of the technologies and the technologies' associated environmental and efficiency impacts. Long-term performance and durability verification are part of this generic verification protocol.

Also fundamental to this verification program is providing emissions control efficiency information needed for manufacturers to participate in the VRP (EPA/420-R-99-014) and its associated allowance of SIP emissions credits. The data quality objectives given in Section 2.3 were set to meet the emissions control measurement requirements of the VRP. Credit determinations will be made by the EPA, which may require information not included in the verification.

This verification program may receive applications for verification of air pollution control technologies on single engines or multiple engine groupings. (The definitions and limitations for engine groupings are

different for different technologies, and are defined below.) The verification test methods applied will be the same in all cases. However, the applicability of the verification data in regard to the VRP will vary depending on the type of technology and the engines on which the verification tests are conducted.

For some APCT technologies, this protocol identifies engine groups that were selected to represent segments of the mobile diesel engine population. This approach was taken to reduce the testing burden on manufacturers of technologies for which this approach can be defended scientifically. Where applicable, the characteristics of the engine's emissions and the APCT's performance are sufficiently understood to allow application of the results of a single verification to a larger population of engines with sufficient accuracy for the purposes of the VRP. In these cases, the data in verification statements for these test engines will be regarded as having applicability within the segment of the engine population having similar characteristics. In general, the engines were grouped based on:

- PM certification level,
- whether the engine is 2-stroke or 4-stroke, and
- whether the engine is highway or nonroad.

Additional test engine selection factors were considered for emissions control technologies whose interactions with the engines or potential emissions require more detailed enquiry. For some emissions control technologies, engine groupings may not be appropriate and engine-by-specific engine verification testing may be required. In other cases the amount of published performance data for an emissions control technology may be insufficient to support development of appropriate engine groupings within this protocol. Details of the engine selection and the applicability of the results are presented in Section 5.

Implicit in the use of single engine verification tests as predictive of performance over segments of the total engine population is the availability of basic design information (eg., space velocity, catalyst loading) to the APCTVC and the potential technology user to evaluate proper scaling between engines. Alternatively, a manufacturer whose technology is being sold in fixed incremental sizes with published ranges of applicability (eg., model AAA is suitable for 100 to 150 hp engines) will be expected to test on an engine at the most challenging end of the

range of applicability. (In this example, a 150 hp engine.) Verification reports and statements will report the results and the design guidance required to independently extend application of the technology to other engines in the same engine grouping.

To conduct verifications, the APCT manufacturer submits the technology to the APCTVC and proposes the test engine(s) and the engine grouping(s) which the test(s) is to represent. The APCTVC will review the application and provide input as required to ensure that the engines proposed are suitable, that the emission control equipment sizing is correct, and that the engine manufacturer accepts application of the technology to the engine. The equipment/technology will applied to the engine(s) according to the manufacturer's instructions. Verification test results for the engines will be reported in the verification reports and statements. The result will provide the basis for the VRP reviewing regulatory authority to determine the emission reduction capability of the technology.

2.2.1 Highway Engines

As stated above, manufacturers may choose to have their technologies verified on single highway engines and on selected engines representing segments of the highway engine population. Section 5.2 describes the highway engine groupings as a function of emissions control technology type. Testing of emissions control technology intended to control emissions from highway diesel engines will be conducted generally under the provisions of 40 CFR, part 86, subpart N. The primary emissions measurements will be of NOx, PM, HC, CO, and CO_2. Each engine in the test will be loaded by a dynamometer as described in the transient Federal Test Procedure (FTP). Each verification test will consist of a single full FTP (cold start and valid hot-start) test on the base-line engine, the de-greened engine, and the aged engine. Emissions reductions will be computed relative to the baseline engine emissions. The verification test is described in detail in Section 5.1.

2.2.2 Nonroad Engines

As for highway engines, manufacturers may select the engines on which to test their technologies. Section 5.4 describes engine groupings for nonroad diesel engine as a function of the emissions control technology type. The verification testing of emissions from nonroad diesel engines

will be conducted generally within the requirements of 40 CFR, part 89, subpart E. As for highway engines, the primary emissions measurements will be of NO_x, PM, HC, CO and CO_2. The verification testing will consist of a single nonroad steady-state mode test as described in 40 CFR, part 89, subpart E, as described in Section 5.5. The test may be conducted over all modes of the test or over portions selected by the APCT manufacturer. Each verification test will consist of a single full FTP test on the base-line engine, the de-greened engine, and the aged engine. Emissions reductions are computed relative to the baseline engine emissions. The emissions results will be reported mode-by-mode to allow flexibility in use of the data for different engine applications.

2.2.3 Control Technologies

This GVP is specifically intended to include the following emissions control technologies:

- active and passive after-treatment fixed bed catalysts and PM filters,
- selective catalytic reduction (SCR),
- fuels and reformulations,
- fuel additives,
- emulsified fuels, and
- engine modifications.

The basic verification test remains the same for all emissions control technologies. However, the technologies interact differently with the various engine technologies. Therefore the engine grouping concept is applied differently depending of the nature of the technology. In addition, technologies that require particular fuel characteristics or have other restrictions must specify them and any associated requirements in their ETV applications.

2.2.4 Relationship of ETV program to Certification Testing

As of the date of this protocol, emissions certification test data from a full FTP test (whether highway or nonroad) have been determined by the EPA to constitute a valid data set for VRP purposes for the particular engine family(s) to which the certification applies. However, certification data do not pass though the ETV verification process and the two processes are independent.

2.3 Data Quality Objectives (DQOs)

The critical measurements for this verification are the emissions of NO_x, HC, PM, CO, and CO_2. The DQOs of this GVP are met by meeting the requirements of the test methods specified in 40CFR Parts 86 or 89 for highway and nonroad diesel engines, respectively. Verification tests that do not meet the FTP QA requirements must be repeated.

In accordance with the FTP, multiple hot-start transient tests may be run sequentially to ensure that a valid hot-start test is obtained economically during any particular test sequence. If multiple valid hot-starts are completed, the results of the valid tests will be averaged and the average will be the result of the ETV test.

A manufacturer may conduct privately-sponsored tests at a test laboratory for development purposes with the same test engine prior to and/or after conducting ETV tests. However, preparation for the ETV test (submittal of the technology to the APCTVC, discussion of engine selection, preparation of the test/QA plan) must be completed prior to conducting the ETV test itself. In particular, declaration of the test run which is to be the ETV test must be made prior to starting the test, the engine must be brought to a starting point in accordance with the test/QA plan, and the results of that test will be documented and reported in accordance with the test/QA plan. All ETV tests that meet the QA requirements of the FTP are considered valid and will be reported. Section 8.0 addresses a technology manufacturer's options should the technology perform below expectations.

Certification tests conducted at independent labs and which meet the requirements of this GVP will be accepted as verification tests provided the technology is submitted to the APCTVC prior to conducting the test, all QA requirements of the FTP methods are met, and the test and test laboratory meet ETV QA requirements.

Engine emissions are expressed in grams of pollutant per kilowatt-hour (g/kWh). The primary measurement of HC and NO_x is normally concentration in the exhaust stream in parts per million by volume (ppmv), which is then converted to g/kWh. For calculation of the technologies removal efficiency, the baseline emissions of the tested engine must also be known. The control technology performance will be reported as both absolute emissions in g/kWh and as percentage reductions for a specific engine or engine family.

3.0 VERIFICATION TESTING RESPONSIBILITIES

This verification testing program is conducted by the APCTVC under the sponsorship of the EPA and with the participation of technology manufacturers/vendors. The APCTVC is operated under a cooperative agreement by the Research Triangle Institute (RTI), the ETV verification partner. RTI's role as verification partner is to provide technical and administrative leadership and either conduct or manage the conduct of verification testing and reporting. Various subcontractors have roles in the APCTVC under RTI's management.

Verification tests are conducted by qualified test laboratories as subcontractors to RTI as the APCTVC verification partner. Test laboratory-specific verification test/QA plans are prepared by the testing laboratories to meet the requirements of the GVPs, such as this one, approved by the APCTVC.

The test/QA plan includes a chart that presents the test program organization and major lines of communication. The organizations involved in the verification of mobile diesel engine air pollution control technologies are the EPA, RTI, testing laboratory, and technology manufacturer/vendor.

The primary responsibilities for each organization involved in the test program are:

1. The EPA, following its procedures for ETV, reviews and approves GVPs, test/QA plans, verification reports, and verification statements.
2. The APCTVC prepares the GVP, provides oversight of the testing organization, provides a template for test/QA plans, and jointly with EPA reviews and approves the verification test reports and verification statements.
3. The testing organization prepares the test/QA plan in accordance with the GVP, coordinates test details and schedules with the manufacturers/ vendors, conduct the tests, and prepares and revises draft verification test reports and draft verification statements. The testing organization QA staff is responsible for conducting internal QA on test results and reports.
4. EPA and/or APCTVC QA staff, at their discretion, will

conduct technical assessments of the test organization's tests and products.

5. The technology manufacturers/vendors provide complete, commercial-ready equipment for verification testing; provide logistical and technical support, as required; and assist the testing organization with operation and monitoring of the equipment during the verification testing. Each manufacturer/vendor bears a portion of the test cost as defined by a contract or letter of agreement with RTI as the APCTVC manager.

4.0 TECHNOLOGY CAPABILITIES AND DESCRIPTION

The test/QA plan must contain a statement by the technology manufacturer/vendor regarding applicability of the technology.

The test/QA plan will also describe the technology to be verified. The description, provided by the technology manufacturer/vendor, must include: technology name, model number, manufacturer's name and address, serial number or other unique identification, warning and caution statements, capacity or throughput rate, and other information necessary to describe the specific technology and its intended use. Warranty information on the technology in the intended application should be provided. The test/QA plan will also include a draft verification statement, based on Appendix A, and be customized to the specific technology being verified and measurements being made.

Other descriptive information the vendor should provide for inclusion in the verification report, as applicable, may include:

1. Installation requirements:
   a. Space occupied,
   b. Installation time,
   c. Modifications,
   d. Startup and shakedown time,
   e. Ancillary equipment, if any, and
   f. Any other special requirements.
2. Operator or mechanic qualifications/training/safety:
   a. Qualifications needed to operate and service the technology,
   b. Amount and type of training needed for operation and maintenance, and
   c. Special safety considerations.
3. Maintenance requirements:
   a. Recommended maintenance procedures and
   b. Spare parts and supplies.
4. Operation:
   a. Fuel requirements (especially fuel sulfur limit),
   b. Impact on engine performance,
   c. Chemicals or other consumable reactants,
   d. Regeneration requirements, and
   e. Device back-pressure.

5. Secondary emissions:
    a. To the air,
    b. That impact water quality, and
    c. Solid waste.
6. Technology's life expectancy.

5.0 TEST PROGRAM

5.1 Verification of Active and Passive Fixed Bed Catalysts and PM Filters (FIXED CATS & FILTERS)

For the purposes of this GVP, fixed bed catalyst devices (usually diesel oxidation catalysts) contain an active catalyst material (often a precious metal) deposited on a ceramic support made up of numerous flow channels. The engine exhaust passes through the device, where the pollutants are sorbed onto walls of the support, catalytically react, and more acceptable reaction products desorb and are exhausted. PM filters are similar, except that direct flow through the support is prevented, and the exhaust must pass through the wall of a closed channel to be exhausted from an adjacent open channel. The particles in the engine exhaust collect on the wall of the closed channel, where they are oxidized catalytically.

Physically, Fixed Cats & Filter devices have the general appearance of a large muffler, and are placed in the engine exhaust at approximately the same location. They are therefore well-suited to retrofit applications. No liquid or gaseous reactants are required for them to function.

Oxidation catalysts have been demonstrated to reduce HC, and CO emissions by over 50%. They reduce PM emissions by about 20%. PM filters have been demonstrated to reduce PM and HC emissions by 80% or more, and to reduce CO at about the level achieved by oxidation catalysts. NOx emissions may be reduced slightly by both fixed cats and filters.

Operational issues with fixed cats and filters are primarily achieving or maintaining adequate temperature within the device to complete the reactions, and avoiding the accumulation of catalyst poisons and/or non-combustible lubricant ash residue accumulation. Lubricant ash can be removed by infrequent “blowing” with compressed air.

5.1.1 General Test Considerations for Fixed Cats & Filters

Fixed Cats & Filters De-greening. For Fixed Cats & Filters, a period of use (de-greening) is needed to achieve a stable emissions reduction. Prior to testing, each device must be de-greened for a period of up to 125 hours (minimum of 50 hours with justification of duration provided by manufacturer) prior to submission for evaluation. De-greening is the responsibility of the retrofit manufacturer and is not

conducted by ETV. De-greening should occur on an engine that is equivalent to the proposed ETV test engine, or at least one which falls within the range of the device's stated applicability. De-greening may occur in a laboratory or during in-use field operations. The retrofit equipment manufacturer must propose and justify the de-greening process in a letter that accompanies the manufacturer's ETV application. A description of the de-greening process will be included in the verification report.

Fixed Cat & Filter Periodic Regeneration. Emissions control devices whose normal operation includes a periodic regeneration will be tested over sufficient test cycles (described below) until a test cycle includes a "regeneration" event. The verified emissions rate and emissions reduction achieved will be computed as the time-weighted average of the emissions rate and reduction achieved over this complete operating cycle. Technologies that are continuously regenerated in normal operation are not the subject of this paragraph.

Fixed Cat & Filter Device Scaling. The performance of Fixed Cat & Filter devices is affected by such reactor operating parameters as space velocity and active catalyst loading. Implicit in the use of single engine verification tests as predictive of performance over segments of the total engine population is the availability of such basic design information to the APCTVC and the potential technology user to evaluate proper scaling between engines. Alternatively, a manufacturer whose technology is being sold in fixed incremental sizes with published ranges of applicability (eg., model AAA is suitable for 100 to 150 hp engines) will be expected to test on an engine at the most challenging end of the range of applicability. (In this example, a 150 hp engine.) Verification reports and statements will report the results and the design guidance required to independently extend application of the technology to other engines in the same engine grouping.

Fixed Cat & Filter Durability Demonstration. The emissions reductions measured for the de-greened Fixed Cat & Filter device will not account for normal degradation in product performance that may occur as the device ages. For participation in the VRP, additional testing of an "aged" control device is required. This is followed by extrapolation of the "initial" and "aged" verified performance measurement to the end of the claimed useful life of the control technology, as described below:

1. Aging entails subjecting the control device to operating conditions that cause normal wear equivalent to at least 25% of the useful life stated in the manufacturer's ETV application. The retrofit manufacturers must conduct the aging process. They have discretion to tailor this process to product requirements. Manufacturers may age a Fixed Cat & Filter device by using it during real-world operation, or through accelerated bench testing. All bench testing protocols must accompany the manufacturer's application and explain the technical basis for stating the protocol results in at least 25% full-life aging. If real-world aging is performed, the application must describe the usage and maintenance history of the aged unit as well as the engine with which it was aged.

2) Emissions testing using the aged device will be part of the ETV verification testing, and will follow the same procedures applied to the de-greened technology. First, baseline emissions testing shall be conducted, followed by testing with the de-greened device, and then finally testing the aged device. If a manufacturer selects to age a unit to its full useful life, emissions testing of the de-greened unit is not necessary for computation of VRP credits.

[*Discussion: from MECA 1/11/01....agree that a durability demonstration is an important feature of the voluntary retrofit program. However, we request that manufacturers have the option of testing using the FTP a product aged to 25% of its warranted life or by testing it over a recognized chassis dynomometer test using recognized test methods as an alternative. We also request that EPA allow the verification of a retrofit emission control technology with the understanding that a durability demonstration will be performed in the future when the appropriate mileage accumulation has been achieved.*

Comment from ETV. Chassis dyno tests can readily be added to the GVP. But need data to show how to reliably relate a chassis dyno test to an engine dyno FTP to allow extrapolation to full life per paragraph below.]

3) Predicting full useful-life reduction capabilities may be accomplished by EPA by using the de-greened emission control performance and the 25% of full-life emission control performance

as two data points that define a straight line that is then extrapolated to the device's full useful-life. (This procedure assumes that technology performance decays linearly after the "de-greening" test.) Emissions control technology manufacturers may present and justify to EPA alternative procedures for estimating emissions reductions achieved over the life of the technology. The predicted emissions reduction, at full-life relative to the baseline, will be the available credit under the VRP. If a technology is aged to its full useful-life before testing, the measured aged unit performance will be used instead of an extrapolated value, and the available credit determined by comparing the baseline and aged unit emissions reductions directly.

Fixed Cat & Filter Test Fuel. The diesel test fuel for highway engines should meet the EPA specifications outlined in 40 CFR §86.1313-98 with the exception of the sulfur content. For nonroad engines the test fuel should be that described in 40 CFR §89.330 or another fuel as specified by the control technology manufacturer. Because the performance and durability of many types of diesel retrofit technology are affected by the sulfur content of the diesel fuel, manufacturers should specify the maximum sulfur level of the fuel for which their technologies are designed. The sulfur content of the verification test fuel should be no less than 66 percent of the stated maximum sulfur content. Other test fuels should meet the applicable EPA specifications outlined in 40CFR §86.1313.

Engine Performance and Power. Engine performance and power will be measured and reported for both the baseline engine (without the control device installed) and the engine with the control device installed. The engine performance measurements in all cases will be made with the engine operating at maximum power at rated conditions and at peak torque at intermediate speed.

Fuel Consumption. Fuel consumption will be measured and reported for both the baseline engine (without the control device installed) and the engine with the control device installed. The engine fuel consumption measurements will be made at maximum power at rated conditions and at peak torque at intermediate speed.

Back-pressure. The back-pressure of a control technology may affect the performance of an engine, and the ETV verification will

measure and report back-pressure for the control device at full-load and rated speed. Back-pressure will be measured and reported for both the baseline engine (without the technology installed) and the engine with the control device installed.

5.1.2 Fixed Cat & Filter Highway Test Engines

The emissions characteristics from diesel engines of the same PM certification level are relatively similar because the engine technologies required to achieve those certification levels are similar. These similarities provide an opportunity to group engines and reduce the verification testing burden on manufacturers. For Fixed Cats & Filters, the verification results for any single engine within a certification level group will be taken as representative of all engines within that level (provided the sizing of the device is the same) for the calculation of SIP credits under the VMEP. Table 1 identifies the engine groupings for Fixed Cats & Filters.

Table 1. Highway Engines for Fixed Cats & Filters

PM Certification Date	PM Certification Level (g/bhp-h)	2-stroke	4-stroke
1990 and before	Uncertified (>0.6) - 0.6	**X**	**X**
1991-1994	0.6 - 0.25	**X**	**X**
1994-1997	0.25 - 0.1	**X**	**X**
1998 and later	<0.1	**X**	**X**

Table 1 shows that by conducting verification tests on 8 highway engines, the performance of a control device can be verified on all highway engines manufactured through the 2001 model year. The control device manufacturer may choose to verify performance within any single, multiple, or all engine groups.

5.1.3 Fixed Cat & Filter Highway Engine Testing

Testing of highway engine technology intended to control emissions from highway diesel engines will be conducted generally under the provisions of 40 CFR part 86 subpart N. The primary emissions measurements will be of NOx, PM, HC, CO and CO_2. Each verification test will consist of a single full highway transient FTP engine dynamometer test (cold start and valid hot-start) test on the base-line engine, the de-greened engine, and the

aged engine. Emissions reductions will be computed relative to the baseline engine emissions. Verification tests that do not meet the FTP QA requirements must be repeated.

In accordance with the FTP, multiple hot-start transient tests may be run sequentially to ensure that a valid hot-start test is obtained economically during any particular test sequence. If multiple valid hot-starts are completed, the results of the valid tests will be averaged and the average will be the result of the ETV test.

The test/QA plan for testing a specific technology will specify the engines that will be tested and any other aspects of the test that are specific to the test laboratory.

5.1.4 Fixed Cat & Filter Nonroad Test Engines

Following an approach similar to that used for the highway engines, nonroad engine groups have been identified as shown in Table 2.

As for highway engines, manufacturers may select the engines on which to test their technologies.

5.1.5 Fixed Cat & Filter Testing on Nonroad Engines

The verification testing will consist of a single nonroad steady-state mode test as described in 40 CFR, part 89, subpart E, as described in Section 5.5. The primary emissions measurements will be of NO_x, PM, HC, CO and CO_2.

Each verification test will consist of a single full steady-state multimode FTP test on the base-line engine, the de-greened engine, and the aged engine. The test may be conducted over all modes of the test or over portions selected by the APCT manufacturer. Test cycle substitution as per Section 89.410(a)(5) is allowed.

Emissions reductions are computed relative to the baseline engine emissions. The emissions results will be reported mode-by-mode to allow flexibility in use of the data for different engine applications.

Table 2. Nonroad Engines for Fixed Cats & Filters

Certification Date	PM Certification Level (g/kWh)	NOx Certification Level (g/kWh)	2-stroke	4-stroke
1996 - and earlier	0.8 - 1	14	X	X
Tier 1	0.5 - 0.7	9	X	X
Tier 2	0.2 - 0.4	6	X	X

5.1.6 Fixed Cat & Filter Control Device ETV Testing

As described above, the control device will be tested using the appropriate test cycle(s) to demonstrate emissions reductions. Baseline testing will be conducted on the engine prior to the test performed for equipment evaluation. The baseline test will be performed without the control device installed. Should there be significant variation compared to previous baseline tests, the cause of such variation will be investigated and identified and necessary maintenance performed to bring baseline emissions levels into an acceptable range prior to retrofit equipment evaluation. Prior to the baseline test, the test engine will undergo a procedure to determine MAP. Fuel consumption, engine performance, and back-pressure readings will be made during the baseline test.

5.2 Verification of SCR Control Devices

SCR control devices catalytically reduce NO_x in the exhaust stream to N_2 through a reaction with an injected chemical, usually an aqueous urea solution. The control device consists of a chemical metering and injection system with a downstream fixed bed catalyst device.

5.2.1 General Test Considerations for SCR Control Devices

Verification testing of SCR systems is identical to that for Fixed Cats & Filters, with the addition of monitoring the chemical consumption rate and analysing the exhaust stream for nitrogenous chemical byproducts (eg., ammonia).

5.2.2 SCR Control Device ETV Testing

In addition to those items identified for Fixed Cats & Filters, the test/QA plan for an SCR verification test must describe the means by which chemical reactant consumption will be monitored. In addition, the test/QA plan will describe the analysis procedure for nitrogenous compound emissions.

5.3 Verification of Fuels and Reformulations (Fuels & Reforms)

For the purposes of this GVP, the fuels and reforms category is defined as new or reformulated fuels that:

1) have approximately the same volumetric energy content as conventional diesel fuels, and
2) do not contain additives requiring EPA registration, and
3) have been endorsed by the engine manufacturer as suitable for use in the proposed test engine without modification, and
4) are neither known nor expected to have any residual impact on the baseline operation of the test engine.

As implied by the requirement for engine manufacturer endorsement, engine durability demonstration is the responsibility of the fuel & reforms manufacturer. Fuels that do not meet all of these criteria will be verified under the procedure for emulsions and fuel additives, section 5.4.

The manufacturer must specify the following properties of the fuel when submitting it:

1) cetane number,
2) energy content,
3) lubricity,
4) sulfur content,
5) corrosion properties as determined by _____, and
6) cold flow filter plugging as determined by _____.

The fuel must be identified unambiguously within the marketplace.

Because use of the fuels & reforms have been endorsed by engine manufacturers, use of the engine groupings in Tables 1 and 2 is acceptable.

Verification testing for fuels & reforms will be identical to that for Fixed Cats and Filters, except that the verification for each engine will consist of only baseline testing on the standard verification fuel followed by verification of emissions performance after at least 16 hours of operation. Engine aging is not required because these fuels, by definition, do not have a residual impact on emissions from the engine. As for all verification tests, the baseline engine will be mapped on standard fuel prior to the test, then remapped with the candidate fuel when conducting the verification test.

5.4 Verification of Emulsions and Fuel Additives (Emuls & Adds)

For the purposes of this GVP, the emuls & adds category is defined as fuels that:

1) do not have approximately the same volumetric energy content as conventional diesel fuels, or
2) contain additives requiring EPA registration, or
3) have not been endorsed by the engine manufacturer as suitable for use in the proposed test engine without modification, or
4) are known or reasonably expected to have a residual impact on the baseline operation of the test engine.

These fuels may reasonably be expected to have effects on fuel systems and engines that are highly specific to the particular engine/fuel system tested. For that reason, testing must be conducted on the engine or fuel system for which verification is proposed, and Tables 1 and 2 are not applicable.

Some fuel additives accumulate in engines, and have been known to have an impact on baseline emissions from that engine for an extended period. When this effect is reasonably expected, the manufacturer of the emul & add will be required by the APCTVC to provide the test engine to the test laboratory or to make provision for returning the engine to its baseline state as part of the cost of verification.

5.4.1 Specific Test Considerations for Emuls & Adds

The manufacturer must specify the following properties of the emul & add fuel when submitting it:

1) cetane number,
2) energy content,
3) lubricity,
4) sulfur content,
5) corrosion properties as determined by _____,
6) cold flow filter plugging as determined by _____, and
7) nature of the additive in sufficient detail for the APCTVC to evaluate its probable impact on the verification engines.

The fuel must be identified unambiguously within the marketplace.

Once a test engine is identified and provided, verification testing will proceed as described for fuels & reforms, Section 5.3. The testing will consist of a baseline test on standard fuel, a verification test with the candidate fuel after a stabilization period of time equal to the de-greening period for fixed cats & filters, and an aged engine verification after 1000 hours of operation on the emul & add.

If the engine manufacturers have not endorsed use of the Emuls & Adds on the proposed test engine, the APCTVC will receive durability data sets from the emuls & adds manufacturer. These data will be submitted under subcontrant to an independent engine test laboratory or consultant for evaluation as the initial step in verification. Verification testing will begin only after the consultant issues a report stating that the data shows that engines fueled by the emul & add can be expected to operate satisfactorily for the period between scheduled major engine and fuel system overhauls. Part of the consultants task will be notification of and solicitation of comments from the engine manufacturer. Any reservations on the part of the engine manufacturer will be noted in the report and, if still in force, on the verification statement.

5.5 Verification of Engine Modifications (Engine Mods)

Engine mods are defined as any uncertified change, internal to a certified engine, that is proposed as an emissions reduction technology.

5.5.1 General Test Considerations for Engine Mods

Engine mods are by their nature specific to the engine being tested, and the use of the engine groupings of Tables 1 and 2 is not possible. Engine mods whose use is endorsed by engine manufacturers are taken to have no

adverse impact on engine durability. Those that are not so endorsed will be evaluated as described in Section 5.4 for emuls & adds. Tthe APCTVC will receive durability data sets from the engine mods manufacturer. These data will be submitted under subcontrant to an independent engine test laboratory or consultant for evaluation as the initial step in verification. Verification testing will begin only after the consultant issues a report stating that the data shows that engines utilizing the engine mod can be expected to operate satisfactorily for the period between scheduled major engine overhauls. Part of the consultants task will be notification of and solicitation of comments from the engine manufacturer. Any reservations on the part of the engine manufacturer will be noted in the report and, if still in force, on the verification statement.

6.0 REPORTING AND DOCUMENTATION

This section describes the procedures for reporting data in the Verification Report and the verification statement. The specifics of what data must be included and the format in which the data must be included are addressed in this section (e.g., QA/QC summary forms, raw data collected, photographs / slides / video tapes). The verification test report for each technology is expected to be about 25-50 pages in length and will include the verification statement as an addendum at the front of the report. The verification statement is a two- to five-page summary of the verification results. An example draft is attached as Appendix A. The Verification Report, including the draft verification statement, will be finalized by the APCTVC from the verification test report submitted by the testing organization. The VR and VS will be reviewed by the APCTVC before being submitted to EPA for review and approval as specified in the ETV QMP.

6.1 Reports

The testing organization will prepare a verification test report that thoroughly describes and documents the verification testing that was conducted and the results of that testing. The test report shall include the following topics:

- Draft VS,
- Introduction,
- Description and identification of product tested,
- Procedures and methods used in testing,

- Statement of operating range over which the test was conducted;
- Summary and discussion of results:
  - Support verification statement,
  - Explain and document necessary deviations from test plan,
  - Discussion of QA and QA statement;
- Conclusions and recommendations;
- References; and
- Appendices:
  - QA/QC activities and results,
  - Raw test data, and
  - Equipment calibration results.

The verification statement will include the following:

- APCT manufacturer/vendor information,
- Summary of verification test program,
- Results of the verification test,
- Any limitations of the verification results, and a
- Brief QA statement.

Review and approval of the draft verification report and statement are as described in Section 3.0. A draft verification statement is attached as Appendix D.

6.2 Data Reduction

Data from measurements made as part of the verification test will be reported as emissions rates in g/kW-hr and as percentage emission reductions from the baseline engine.

7.0 DISSEMINATION OF VERIFICATION REPORTS AND STATEMENTS

After a retrofit control technology has been tested and the draft report and verification statement received from the testing organization, the APCTVC will send a draft of both to the manufacturer/ vendor for review prior to submission to EPA and release to the public. This gives the manufacturer/vendor an opportunity to review the results, test methodology, and report terminology while the drafts remain working

documents and are not publically accessible. The manufacturer/vendor may submit comments and revisions on the draft statement and report to the APCTVC. The APCTVC will consider these comments and may suggest revisions of its own. The revised verification report and verification statement will be returned to the manufacturer/vendor for final review.

After final review by the manufacturer/vendor and review by the APCTVC, the draft final verification report and statement will be submitted to EPA for review and approval. Following approval, several copies of the verification report will be provided to the manufacturer/vendor. Distribution of the final verification report, if desired, is at the manufacturer/vendor's discretion and responsibility.

Approved verification statements and reports will be posted on the ETV web site for public access without restriction. An original signed verification statement and report will be provided to the manufacturer/ vendor of the control technology.

8.0 MANUFACTURER/VENDOR'S OPTIONS IF A TECHNOLOGY PERFORMS BELOW EXPECTATIONS

ETV is not a technology research and development program; technologies submitted for verification are to be commercial-ready and with well-understood performance. Tests that meet the verification data quality requirements are considered valid and suitable for publishing. In the event that a technology fails to meet the manufacturer's expectations, the manufacturer/vendor may request that a verification statement not be issued. However, verification tests are always in the public domain. Verification reports will be written and will be available from EPA for review by the public regardless of a request not to issue a verification statement.

The manufacturer may improve the product and resubmit it under a new model identification for verification testing. Verification statements for tests of the new product will be issued as they are processed by the APCTVC and EPA (except that the results for several identical tests performed in rapid succession will all be released at the same time.)

9.0 LIMITATIONS ON TESTING AND REPORTING

To avoid having multiple ETV reports for the same product and to maintain the verification testing as a cooperative effort with manufacturer/vendors, the following restrictions apply to verification testing under this protocol:

- Manufacturer/vendors may submit only their own products for testing; manufacturer/vendors may not submit control devices from other manufacturers for verification testing.
- For a given product (e.g., brand and model), APCT policy is that only one ETV verification report and statement will be issued for any single application.
- Air pollution control technology frequently performs differently in different applications. Manufacturer/vendors may request additional tests of essentially identical technology if it is being applied to pollution sources that are clearly different from those for which verifications have been obtained.

10.0 REQUIREMENTS FOR TEST/QA PLAN

10.1 Quality Management

All testing organizations participating in the Verification of Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines program must meet the QA/QC requirements defined below and have an adequate quality system to manage the quality of work performed. Documentation and records management must be performed according to the *ETV Quality and Management Plan for the Pilot Period (1995-2000)* (ETV QMP, EPA, 1998a.) Testing organizations must also perform assessments and allow audits by the APCTVC (headed by the APCT QA Officer) and EPA corresponding to those in Section 11.

All testing organizations participating in the Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines Program must have an ISO 9000-accredited (ISO, 1994) or ANSI E4-compliant (ANSI, 1994) quality system and an EPA- or APCTVC-approved QMP. The APCTVC will approve the QMP of the testing organization.

10.2 Quality Assurance (QA)

All verification testing will be done following an approved test/QA plan that meets *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1998c) and Part B, Section 2.2.2 of EPA's ETV QMP (EPA, 1998a). These documents establish the requirements for test/QA plans and the common guidance document, *Guidance for Quality Assurance Project Plans* (EPA, 1998b), provides guidance on how to meet these requirements. The APCT Quality Management Plan (RTI, 1998) implements this guidance for the APCTVC. The test/QA plan must describe how the methods described in Appendix A of this generic verification protocol will be implemented by the testing organization and the steps the testing organization will take to ensure acceptable data quality in the test results. Any needed standard operating procedures (SOPs) will be developed in accordance with *Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents* (EPA, 1995.)

The testing organization must prepare a test/QA plan and submit it for approval by the APCTVC. The test/QA plan must be approved before the test organization can begin verification testing.

A test/QA plan contains the following elements. If specific elements are not included, an explanation for not including them must be provided.

- Title and approval sheet;
- Table of contents, distribution list;
- Test description, test objectives;
- Identification of the critical measurements, data quality objectives (DQOs) and indicators, test schedule, and milestones;
- Organization of test team and responsibilities of members of that team;
- Documentation and records;
- Test design;
- Sampling procedures;
- Sample handling and custody;
- Analytical procedures;
- Test-specific procedures for assessing data quality indicators;
- Calibrations and frequency;
- Data acquisition and data management procedures;
- Internal systems and performance audits;

- Corrective action procedures;
- Assessment reports to EPA;
- Data reduction, data review, data validation, and data reporting procedures;
- Reporting of data quality indicators for critical measurements;
- Limitations of the data; and
- Any deviations from methods from this generic verification protocol.

10.3 Additional Requirements To Be Included in the Test/QA Plan

The test/QA plan must include a diagram and description of the extractive gaseous measurement system to be used for the testing and a list of the reference analyzers and measurement ranges to be used for quantifying the gaseous concentrations. Additional analyzers (CO and THC) in the sampling system diagram must also be included, as well as a list of the reference analyzers and measurement ranges to be used for quantifying CO and THC concentrations.

The test/QA plan must include a schematic of all sample and test locations, including the inlet and outlet to the technology sampling locations. The location of flow disturbances and the upstream and downstream distances from the sampling ports to those flow disturbances must be noted. The number of traverse points that will be sampled must be provided.

The test/QA plan must include the appropriately detailed descriptions of all measuring devices that will be used during the test.

The test/QA plan must explain the specific techniques to be used for monitoring process conditions appropriately for the source being tested. It must also note the techniques that will be used to estimate any other operational parameters.

11.0 ASSESSMENT AND RESPONSE

The APCTVC and/or EPA will conduct assessments to determine the testing organization's compliance with its test/QA plan. The requirement to conduct assessments is specified in EPA's *Quality and Management Plan for the Pilot Period (1995 - 2000)* (EPA, 1998a), and in RTI's QMP

(RTI, 1998.) EPA will assess RTI's compliance with RTI's test/QA plans. RTI will assess the compliance of other organizations with their test/QA plans. The assessments will be conducted according to *Guidance on Technical Assessments for Environmental Data Operations* (EPA, 1999.)

11.1 Assessment Types

Technical systems audit - Qualitative on-site audit of the physical setup of the test. The auditors determine the compliance of testing personnel with the test/QA plan.

Performance evaluation audit - Quantitative audit in which measurement data are independently obtained and compared with routinely obtained data to evaluate the accuracy (bias and precision) of a measurement system.

Audit of data quality - Qualitative and quantitative audit in which data and data handling are reviewed and data quality and data usability are assessed.

11.2 Assessment Frequency

Activities performed during technology verification performance operations that affect the quality of the data shall be assessed regularly, and the findings reported to management to ensure that the requirements stated in the generic verification protocols and the test/QA plans are being implemented as prescribed.

The types and minimum frequency of assessments for the ETV Program are listed in Part A Section 9.0 of EPA's *Quality and Management Plan for the Pilot Period (1995 - 2000)*. Tests conducted during the APCTVC will have at a minimum the following types and numbers of assessments:

1. Technical systems audits – self-assessments for the test as provided for in the test/QA plan and independent assessments. Two will be conducted for the APCTVC.
2. Performance evaluation audits – self-assessments, as applicable, for each test as provided in the test/QA plan and independent assessments, as applicable for each different technology verified by the APCTVC.
3. Audits of data quality – self-assessments of at least 10% of all the

verification data; and independent assessment, as applicable for the APCTVC.

The independent assessments of tests conducted by RTI will be performed by EPA. The independent assessments of other organizations will be by RTI.

11.3 Response to Assessment

Appropriate corrective actions shall be taken and their adequacy verified and documented in response to the findings of the assessments. Data found to have been taken from non-conforming technology shall be evaluated to determine its impact on the quality of the required data. The impact and the action taken shall be documented. Assessments are conducted according to procedures contained in the APCT QMP. Findings are provided in audit reports. Responses by the testing company to adverse findings are required within 10 working days of receiving the audit report. Followup by the auditors and documentation of responses are required.

12.0 SAFETY MEASURES

12.1 Safety Responsibilities

The test organization's project leader is responsible for ensuring compliance with all applicable occupational health and safety requirements. Each individual staff member is expected to follow the requirements and identify personnel who deviate from them and report such action to their supervisor.

12.2 Safety Program

The test company must maintain a comprehensive safety program and ensure that all test personnel are familiar with and follow it.

13.0 REFERENCES

ASQC. *AMERICAN NATIONAL STANDARD Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*. ANSI/ASQC E4-1994. Milwaukee, WI. American Society for Quality Control, 1994.

EPA. *Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents. EPA QA/G-6*. EPA 600/R-96/027. http://www.epa.gov/region10/www/offices/oea/epaqag6.pdf Washington, DC. Office of Research and Development, U.S. Environmental Protection Agency, November 1995.

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RTI. *Verification Testing of Air Pollution Control Technology - Quality Management Plan*. Air Pollution Control Technology Program. J. R. Farmer, Program Director, Research Triangle Institute, Research Triangle Park, NC. 1998.

U.S. Government. 1999. Protection of Environment. Title 40, Part 86, Code of Federal Regulations, as of July 1, 1999. Office of the Federal Register

U.S. Government. 1999. Protection of Environment. Title 40, Part 89, Code of Federal Regulations, as of July 1, 1999. Office of the Federal Register

APPENDIX A: EXAMPLE VERIFICATION STATEMENT

Appendix A is an example verification statement originally written for a generic NO_x control technology, and only slightly modified. This generic verification statement is intended only to show the form of a verification statement. It will require modification for each technology verified, depending on the details of that technology's design, construction, and operation. The test/QA plan written for each test will include a draft verification statement customized for the technology actually being tested. The text of that specific verification statement will address the significant parameters that actually apply to the technology tested.

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Research Triangle Institute

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**MOBILE DIESEL ENGINE AIR POLLUTION CONTROL TECHNOLOGY**		
APPLICATION:	**CONTROL OF EMISSIONS FROM MOBILE DIESEL ENGINES IN (*HIGHWAY*) (*NONROAD*) USE BY (*TECHNOLOGY TYPE ID*)**		
TECHNOLOGY NAME:	**TECHNOLOGY NAME**		
COMPANY:	**COMPANY NAME**		
ADDRESS:	**ADDRESS** **CITY, STATE ZIP**	**PHONE:** **FAX:**	**(000) 000-0000** **(000) 000-0000**

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups which consist of buyers, vendor organizations, permitters, and other interested parties; with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Air Pollution Control Technology (APCT) program, one of 12 technology areas under ETV, is operated by the Research Triangle Institute (RTI), in cooperation with EPA's National Risk Management Research Laboratory. The APCTVC has evaluated the performance of a _____*TYPE*_____ technology for mobile diesel engines, the *TECHNOLOGY NAME* by *COMPANY NAME*.

VERIFICATION TEST DESCRIPTION

All tests were performed in accordance with general guidance given by the APCTVC "Generic Verification Protocol for Retrofit Air Pollution Control Technologies for Highway and Non-Road Use Diesel Engines" and the specific technology test plan "Verification Test/QA Plan for *TECHNOLOGY NAME*". These documents include requirements for quality management, quality assurance, procedures for product selection, auditing of the test laboratories, and test reporting format.

The mobile diesel engine air pollution control technology was tested as installed and operating on the following engine(s) at *TEST LABORATORY*. The engine(s) on which the performance of the technology was verificd are described in Table D-1. The test cycle consisted of a single complete transient federal test procedure per 40CFR, part 86, subpart N, that met all QA requirements for the test.

Table D-1. Test Engine(s)

Engine Identification	**MAKEADIESEL AAAAAAAA**	**MAKEADIESEL BBBBBBBB**	**MAKEADIESEL CCCCCCCC**
2- or 4-cycle			
Year of manufacture			
PM emissions certification category			
Engine Power			
Highway or Nonroad			

In addition to outlet emissions concentrations and the primary operating parameters, a number of other emissions of importance for the NO_x control technology were also measured using EPA standard methods, and the energy use rates, staffing, maintenance requirements, and similar issues were noted qualitatively.

TECHNOLOGY DESCRIPTION

This verification statement is applicable to the TECHNOLOGY NAME (to include model number and other identifying information as needed) ....

Control of these other pollutants is not a topic included in this generic verification protocol.

This verification statement covers application of TECHNOLOGY NAME to small- and medium-sized stationary combustion sources fueled by natural gas. TECHNOLOGY NAME is characterized by .... *(Descriptive language provided by technology vendor.)*........... ....

VENDOR'S STATEMENT OF PERFORMANCE

TECHNOLOGY NAME is capable of achieving a NO_x emission concentration of _______ ppmv when operated at a Parameter A value*(s)* of _____ and [specify process operating conditions] and of controlling NO_x emissions to below _______ ppmv when operated at a Parameter A value of _____ and [specify different process operating conditions]. *(Note that this example statement of performance assumes a single significant parameter, A. Additional parameters may be required for a particular technology.)*

VERIFICATION OF PERFORMANCE

Verification testing of TECHNOLOGY NAME was performed from ______ through _______, at an installation on a natural-gas-fired combustion source in State or Region. The results are given in Table 2.

TECHNOLOGY NAME

Table 2. Control technology performance

Engine Identification	**Reduction in emissions from baseline operation, percent**				
	NOx	**PM**	**HC**	**CO**	**Device Sizing Info**
DIESEL A Degreened					
Diesel A Aged					
Diesel B Degreened					
DIESEL B Aged					
DIESEL C Degreened					

DIESEL B Aged					
DIESEL C					

The APCT quality assurance (QA) Officer has reviewed the test results and quality control data and has concluded that data quality objectives given in the generic verification protocol and test/QA have been attained.

During the verification tests, EPA and/or APCT quality assurance staff conducted technical assessments at the test laboratory, which confirm that the verification test was conducted in accordance with the test laboratory's EPA-approved test/QA Plan.

This verification statement verifies the NO_x emissions characteristics of TECHNOLOGY NAME within the stated range of application. Extrapolation outside that range should be done with caution and an understanding of the scientific principles that control the performance of TECHNOLOGY NAME. Users with NO_x control requirements should also consider other performance parameters such as service life and cost when selecting a NO_x control system.

In accordance with the generic verification protocol, this verification report is valid commencing on DATE indefinitely for application of TECHNOLOGY NAME within the range of applicability of the statement.

E. Timothy Oppelt Date
Director
National Risk Management Research Laboratory
Office of Research and Development
United States Environmental Protection Agency

Jack R. Farmer Date
Program Manager
Air Pollution Control Technology Program
Research Triangle Institute

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2